The University of Tennessee

Microsensors for Ultrasensitive Detection of Hexavalent Chromium in Ground Water

Technology Need:

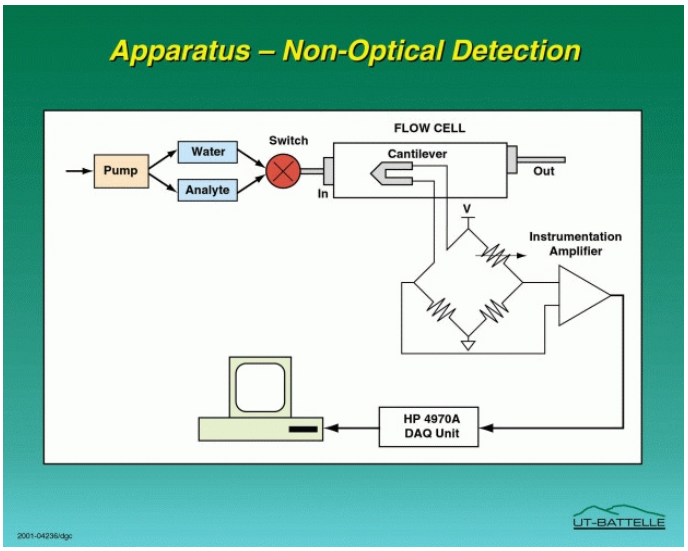
DOE needs remote characterization of the physical and chemical characteristics of groundwater, sediments, and mixed wastes. Immediate need involves real-time, continuous monitoring of chromium in ground water with a sensitivity of 1 µg/L. Chromium exists in different oxidation states in ground water and soil. Cr(III) - trivalent chromium - is an essential trace element in the human body, but Cr(VI) - hexavalent chromium, in the form CrO_4^{2-}, is toxic to animals and humans. Furthermore, CrO_4^{2-} is stable in neutral and alkaline environments. Current methods used to determine CrO_4^{2-}, such as extraction, ion-exchange, chromatography, and atomic absorption spectroscopy are time-consuming, have less than desired accuracy, or are expensive. Therefore, developing new sensitive techniques for the *in situ* detection of CrO_4^{2-} in the environment with high sensitivity and selectivity has immediate relevance in environmental remediation and monitoring.

Technology Description:

The objective of this project is to develop in-situ, portable sensors for continuous monitoring of CrO_4^{2-} in ground water using adsorption-induced stress on micromachined microcantilevers. Detection of CrO_4^{2-} with a sensitivity of 52 nanogram/liter has been demonstrated under laboratory conditions. Development of sensors for ground water poses several challenges that will be addressed in this project, including optimization of cantilever response in water and minimizing interference from other compounds (using an array of microcantilevers).

The microcantilever method exhibits high sensitivity based on the ability to detect cantilever motion with subnanometer precision and the ability to micromachine cantilevers into a multi-element array. No other technology offers such versatility.

The deflections of a microcantilever can be measured with sub-Angstrom resolution using current techniques perfected for Atomic Force Microscopy, such as optical reflection, piezoresistive, capacitance, and piezoelectric detection methods. One great advantage of the cantilever technique is that five response parameters (resonance frequency, phase, amplitude, Q-factor, and deflection) can be simultaneously detected.



The miniature size and low cost would permit widespread deployment. Telemetry could be incorporated for local transmission of selected data, broadening the potential application of the sensors in the remediation field.

The microcantilever concept will serve as a general platform for a myriad of extremely sensitive, highly selective real-time microsensors that can be mass-produced using conventional techniques.

Once the basic platform for cantilever sensors is

developed, it can be the basis for a plethora of inexpensive, miniature sensors including those for the detection of strontium-90 and DNPLs.

Benefits:

- Extremely high (in the nanogram/liter range) sensitivity has been demonstrated for Cr.

- Highly selective detection in the presence of chemical interference.

- Low power consumption is predicted, based on lab testing.

- Small size: the entire sensor, including lever, transducer, and electronics should take up only a few cubic inches.

Status and Accomplishments:

The contractor is testing coatings for microcantilevers for long-term sensitivity to Cr and repeatability for a large number of Cr detection iterations. Detection procedures that improve performance are being evaluated. The contractor is developing techniques to optimize the cantilever response to Cr ions, including minimizing the overall response to interferences such as other chemicals, and variation in ambient temperature, pressure, vibration, etc. Success will be judged by the ultimate detection sensitivity achieved and measuring the response of the detector to interferences. If successful, development of field-portable sensors will proceed.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 3175
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov